TWENTY-SIXTH ANNUAL REPORT

OF THE

Maine Agricultural Experiment Station

ORONO, MAINE.

1910

STATE OF MAINE.
1911.

MAINE
AGRICULTURAL EXPERIMENT STATION
ORONO, MAINE.

Organization January to June, 1910.

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The publications of this Station will be sent free to any address in Maine. All requests should be sent to

Agricultural Experiment Station,
Orono, Maine.

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ANNOUNCEMENTS.

Establishment of the Station.

The Maine Fertilizer Control and Agricultural Experiment Station, established by Act of the Legislature approved March 3, 1885, began its work in April of that year in quarters furnished by the College. After the Station had existed for two years, Congress passed what is known as the Hatch Act, establishing agricultural experiment stations in every state. This grant was accepted by the Maine Legislature by an Act approved March 16, 1887, which established the Maine Agricultural Experiment Station as a department of the University. The reorganization was effected in June, 1887, but work was not begun until February 16, 1888. In 1906 Congress passed the Adams Act for the further endowment of the stations established under the Hatch Act.

The purpose of the experiment stations is defined in the Act of Congress establishing them as follows:

"It shall be the object and duty of said experiment stations to conduct original researches or verify experiments on the physiology of plants and animals; the diseases to which they are severally subject, with the remedies for the same; the chemical composition of useful plants at their different stages of growth; the comparative advantages of rotative cropping as pursued under a varying series of crops; the capacity of new plants or trees for acclimation; the analysis of soils and water; the chemical composition of manures, natural and artificial, with experiments designed to test their comparative effects on crops of different kinds; the adaptation and value of grasses and forage plants; the composition and digestibility of the different kinds of food for domestic animals; the scientific and economic questions involved in the production of butter and cheese; and such other researches or experiments bearing directly on the agricultural industry of the United States as may in each case be deemed advisable, having due regard to the varying conditions and needs of the respective states or territories."

The work that the Experiment Station can undertake from the Adams Act fund is more restricted and can "be applied only to paying the necessary expenses of conducting original researches or experiments bearing directly on the agricultural industry of the United States, having due regard to the varying conditions and needs of the respective states and territories."

Any resident of Maine concerned in agriculture has the right to apply to the Station for any assistance that comes within its province.

INVESTIGATIONS.

The Station continues to restrict its work to a few important lines, believing that it is better for the agriculture of the State to study thoroughly a few problems than to spread over the whole field of agricultural science. It has continued to improve its facilities and segregate its work in such a way as to make it an effective agency for research in agriculture. Prominent among the lines of investigation are studies upon the food of man and animals, the diseases of plants and animals, breeding of plants and animals, orchard and field experiments, poultry investigations, and entomological research.

INSPECTIONS.

The inspection of food and drugs, the inspection of fertilizers, the inspection of concentrated commercial feeding stuffs, the inspection of agricultural seeds, and the testing of the graduated glassware used in creameries, are entrusted to the Station through its director, who is responsible for the execution of the public laws relating to these matters. The cost of the inspections is borne by a state appropriation, and the examination of chemical glassware by a charge for calibration.

OFFICES AND LABORATORIES.

The offices, laboratories and poultry plant of the Maine Agricultural Experiment Station are at the University of Maine, Orono. Orono is the freight, express, post, telegraph and telephone address for the offices and laboratories.

Visitors to the Station will find it convenient to leave the steam cars at Bangor or Old Town, as the railway station at

Orono is a mile from the University. Bangor and Old Town trolley cars pass through the campus. They pass the railway station in Bangor 5 minutes after the hour and half hour, and the railway station in Old Town, 20 minutes after and 10 minutes before the hour.

HIGHMOOR FARM.

Highmoor Farm, purchased by the State for the use of the Station, is located in the town of Monmouth, 2½ miles from the Monmouth station and the same distance from the Leeds Junction station. It is on the Farmington branch of the Maine Central Railroad. A flag station, called Highmoor, is on the farm. Monmouth is the post, telegraph and telephone address for Highmoor Farm. Both Leeds Junction and Monmouth are freight and express addresses.

Visitors are always welcome. Granges, Farmers' Clubs and others desiring to visit Highmoor Farm are requested to arrange dates in advance.

THE AIM OF THE STATION.

Every citizen of Maine concerned in agriculture has the right to apply to the Station for any assistance that comes within its province. It is the wish of the Trustees and Station Council that the Station be as widely useful as its resources will permit.

In addition to its work of investigation, the Station is prepared to make chemical analyses of fertilizers, feeding stuffs, dairy products and other agricultural materials; to test seeds and creamery glassware; to identify grasses, weeds, injurious fungi and insects, etc.; and to give information on agricultural matters of interest and advantage to the citizens of the State.

All work proper to the Experiment Station and of public benefit will be done without charge. Work for the private use of individuals is charged for at the actual cost to the Station. The Station offers to do this work only as a matter of accommodation. Under no condition will the Station undertake analyses, the results of which cannot be published, if they prove of general interest.

CORRESPONDENCE.

As far as practicable, letters are answered the day they are received. Letters sent to individual officers are liable to remain unanswered, in case the officer addressed is absent. All communications, should, therefore, be addressed to the Director or to the

Agricultural Experiment Station,
Orono, Maine.

PUBLICATIONS.

The Station is organized so that the work of investigation is distinct from the work of inspection. The results of investigation are published in the bulletins of the Station. These make up the annual report for the year. The results of the work of inspection are printed in publications known as Official Inspections. These are paged independently of the bulletins and are bound in with the annual report as an appendix thereto. Miscellaneous publications consisting of newspaper notices of bulletins, newspaper bulletins and circulars which are not paged consecutively and for the most part are not included in the annual report are issued during the year.

All of the bulletins issued by the Station are sent to the names upon the official mailing list prepared by the Office of Experiment Stations, to all newspapers in Maine and to libraries and to agricultural exchanges. Bulletins which have to do with general agriculture and the Official Inspections which bear upon the feeding stuffs, fertilizer and seed inspections are sent to a general mailing list composed chiefly of farmers within the State. The publications having to do with the food and drug inspection are sent to a special list including all dealers in Maine and other citizens who request them. The annual report is sent to directors of experiment stations and to libraries. Copies of all publications are sent to the newspapers within the State and to the press on the exchange list outside of the State.

BULLETINS PUBLISHED IN 1910.

Bulletin 176. The Ligaments of the Oviduct of the Domestic Fowl. 20 pages, 9 illustrations.
Bulletin 177. Insect Notes for 1909. 24 pages, 37 illustrations.
Bulletin 178. An Endomyces from Apple. 20 pages, 14 illustrations.
Bulletin 179. Poultry Notes. 60 pages, 10 illustrations.
Bulletin 180. Fungus Gnats of North American. Part II. 68 pages, 65 illustrations.
Bulletin 181. Galls Aphids of the Elm. 48 pages, 72 illustrations.
Bulletin 182. Four Rare Aphid Genera from Maine. 8 pages, 22 illustrations.
Bulletin 183. Experiments in Breeding Sweet Corn. 68 pages, 15 illustrations.
Bulletin 184. Digestion Experiments with Poultry. 20 pages, 2 illustrations.
Bulletin. 185. Maine Apple Diseases. 56 pages, 30 illustrations.
Bulletin 186. Meteorology Finances. Index pages

OFFICIAL INSPECTIONS ISSUED IN 1910.

No. 19. Fertilizer Inspection. 28 pages.
No. 20. Feeding Stuff Inspection. 8 pages.
No. 21. Miscellaneous Food Materials. 8 pages.
No. 22. Miscellaneous Food Materials. 12 pages.
No. 23. Feeding Stuff Inspection. 16 pages.
No. 24. Miscellaneous Food Materials. 12 pages.
No. 25. Food and Drug Regulations. 4 pages.
No. 26. Headache Remedies. 8 pages.
No. 27. Soda Water and Ice Cream. 30 pages.
No. 28. Seed Inspection. 16 pages.

MISCELLANEOUS PUBLICATIONS ISSUED IN 1910.

No. 371. Blackleg, a Bacterial Disease of potatoes. 1 page.
No. 372. Notice to Accompany Bulletin. 1 page.
No. 373. List of Publications, 1909. 1 page.
No. 374. Letter to Shippers of Maine Seed Potatoes. 4 pages.
No. 375. Certain Diseases of Maine Potatoes and Their Relation to the Seed Trade. 12 pages.
No. 376. Seed Potatoes and Late Blight. 1 page.
No. 377. Home-mixed Fertilizers. 20 pages.
No. 378. Oyster-shell Bark Louse. 4 pages.
No. 379. Organic Ammoniates and Mixed Fertilizers. 1 page.
No. 380. Insect Notes for 1909. 1 page.
No. 381. Invitation Anniversary Exercises. 1 page.
No. 382. List Entomological Papers. 16 pages.
No. 383. Apple Tree Insects of Maine. 68 pages.
No. 384. Organization of Station. 1 page.

No. 385. Exercises at the Twenty-fifth Anniversary of the Establishment of the Station. 38 pages.
No. 386. Plant Diseases. 4 pages.
No. 387. Maine Seed Potatoes. 1 page.
No. 388. Experiments at Highmoor Farm, 1910. 4 pages.
No. 389. Apple Tree Insects. 1 page.
No. 390. Poultry Notes. 1 page.
No. 391. List of Bulletins, 1903-1908. 2 pages.
No. 392. Sweet Corn Culture and Breeding. 1 page.
No. 393. Practical Suggestions Regarding the Growing of Sweet Corn. 8 pages.
No. 394. Poultry Notes. Reprint popular part Bulletin 179. 20 pages.
No. 395. Poultry Plant Notice. 1 page.
No. 396. Digestion Experiments with Poultry. 8 pages.
No. 397. Seed Potatoes, Oats and Corn. 4 pages.

BIOLOGY PUBLICATIONS—1910.

In the numbered series of "Papers from the Biological Laboratory."

No. 16. The Ligaments of the Oviduct of the Domestic Fowl. By Maynie R. Curtis. Maine Expt. Sta. Bul. 176, pp. 1-20, 3 plates.
No. 17. On the Inheritance of the Barred Color Pattern in Poultry. By R. Pearl and F. M. Surface. Archiv. f. Entwicklungsmechanik. Bd. XXX (Festband für Roux) I Teil, pp. 45-61. 2 plates.
No 18. Experiments in Breeding Sweet Corn. By R. Pearl and F. M. Surface. Maine Agric. Expt. Sta. Annual Rept. for 1910.
No. 19. Inheritance in "Blood Lines" in Breeding Animals for Performance, with Special Reference to the "200-egg" Hen. By R. Pearl. Ann. Rept. Amer. Breeders Assoc. Vol. VI. (In press).
No. 20. A Biometrical Study of Egg Production in the Domestic Fowl. II. The Seasonal Distribution of Egg Production. By R. Pearl and F. M. Surface. U. S. Dept. Agr. Bur. Anim. Ind. Bulletin 110, Part II.
No. 21. Studies on Hybrid Poultry. By R. Pearl and F. M. Surface. Me. Agr. Expt. Sta. Annual Rept. for 1910, pp. 84-115.
No. 22. Further Data Regarding the Sex Limited Inheritance of the Barred Color Pattern in Poultry. By R. Pearl and F. M. Surface. Science, N. S. Vol. XXXII, pp. 870-874.
No. 23. Data on the Relative Inconspicuousness of Barred and Self-colored Fowls. By R. Pearl, American Naturalist, Vol. XLV, pp. 107-117.

Papers published, but not in the numbered series:

a. Poultry Notes—1910. By R. Pearl and F. M. Surface. Me. Agr. Expt. Sta. Bulletin 179, pp. 65-134.

b. The Relation of the Results Obtained in Breeding Poultry for Increased Egg Production to the Problem of Selection. By R. Pearl. Rept. 30th Meeting Soc. Prom. Agr. Sci. pp. (of reprint) 1-8.

c. Intra-individual Variation and Heredity. By R. Pearl. Proc. Seventh Internat. Zool. Congress. pp. (of reprint) 1-3.

d. The Possible Eugenic Bearing of Certain Experiments with Poultry. By R. Pearl. Eugenic Review, April 1910, Vol. II.

e. Breeding for Production in Dairy Cattle in the Light of Recent Advances in the Study of Inheritance. By R. Pearl. Eighth Ann. Rept. Comm. Agr. Maine, pp. 118-129, 1910.

f. Inheritance of Hatching Quality of Eggs in Poultry. By R. Pearl. Amer. Breeders Mag. Vol. I, pp. 129-133.

ENTOMOLOGY PUBLICATIONS.

No. 41. Bul. 177. Insect Notes for 1909. O. A. J. pp. 21-44.
No. 42. Bul. 180. Fungus Gnats, II, O. A. J. pp. 125-192.
No. 43. Bul. 181. Gall Aphids of the Elm. E. M. P. pp. 193-240.
No. 44. Bul. 182. Four Rare Aphid Genera From Maine. E. M. P. pp. 241-248.

CHANGES IN STATION STAFF.

April 1 Joseph F. Merrill resigned as Assistant Chemist to accept a similar position at the Massachusetts Agricultural Experiment Station.

April 1 Harry M. Woods resigned as Assistant to the Director.

July 1 Alfred K. Burke and Raymond P. Norton were appointed Assistant Chemists.

December 1 Mr. Norton resigned to accept a position with the Bureau of Animal Industry, of the United States Department of Agriculture.

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Maine Agricultural Experiment Station

ORONO

BULLETIN No. 176 JANUARY, 1910

THE LIGAMENTS OF THE OVIDUCT OF THE DOMESTIC FOWL

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BULLETIN No. 176.

THE LIGAMENTS OF THE OVIDUCT OF THE DOMESTIC FOWL.*

By

MAYNIE R. CURTIS.

INTRODUCTION.

The oviduct of a laying hen is a large, much coiled tube filling a large part of the left half of the abdominal cavity. It is suspended from the dorsal body wall and lies dorsal to the abdominal air sac. Its anterior end is expanded into a large funnel which is spread out beneath the ovary in such a way that the mouth of the tube faces the ovary. In certain experimental work on the oviduct which has been for some time in progress in this laboratory, particular interest was aroused by the fact that when the oviduct is in functional (laying) condition the outer portion of its wall in the albumen secreting region is very thin. The main part of the oviduct wall is made up of the thick albumen and membrane secreting glands. The muscular and peritoneal layers are very thin, except in the region of the uterus and vagina. Notwithstanding this fact the oviduct is capable of very marked and long continued peristalsis. One is impressed with the fact that there is apparently a great disproportion between the amount of musculature in the walls of the duct and the degree of physiological activity of this organ. It seems to the observer impossible that so powerful a peristalsis can be maintained solely by so very thin a muscle layer.

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* Papers from the Biological Laboratory of the Maine Experiment Station. No. 16.

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This apparent disproportion between structure and function led to the undertaking of the present investigation. It was desired to determine whether there did not exist some other muscular apparatus besides that intrinsic in the oviduct wall which could aid in the peristaltic activity of the organ. As a matter of fact it was found that there is a highly developed muscular apparatus in the ligaments of the oviduct. This musculature is directly connected with that which is intrinsic in the oviduct. Its existence at once gives the clue to the solution of the puzzle of the apparent disproportion between structure and function in the physiology of the oviduct. It appears that this disproportion is only apparent, not real.

The purpose of the present paper is, (a) to describe the ligaments which suspend the oviduct from the body wall, maintain the convolutions in the tube and hold the funnel in position to receive the mature yolks from the ovary, and (b) to describe the bundles of muscle fibers which occur in these ligaments and are continuous with the musculature of the walls of the oviduct.

THE DEVELOPMENT OF THE OVIDUCT AND ITS LIGAMENTS.

The relation of the oviduct to its ligaments is clear when studied in the light of its origin, development, and growth. The present study began with the oviducts of chicks just out of the shell but in order to make the relations of the duct more easily understood it will be well to begin the account with its origin. The embryological facts presented are taken from Lillie's* description.

The formation of the oviduct is preceded by the thickening of a strip of peritoneum on the surface of the Wolffian body immediately ventral to the Wolffian duct. This strip of thickened peritoneum, the tubal ridge, appears on the fourth day of incubation. It first arises at the anterior end of the Wolffian body and differentiates rapidly backward to the cloaca. Soon after its formation a groove appears at its cranial end. The lips of this groove fuse caudally forming a very short tube open cranially to the abdominal cavity and ending blindly behind. This tube soon separates from the tubal ridge. The lips of the opening into the body cavity form the funnel (*ostium tubac abdominale* or infundibulum) and the short tube forms the cranial end of the tubular portion of the oviduct. The rest of the oviduct arises by the caudal elongation of this short anterior portion which grows backward between the tubal ridge and the Wolffian duct to the cloaca.

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* Lillie, F. R. The Development of the Chick. New York (Holt), 1908.

As development proceeds the duct enlarges and begins to project from the ventral surface of the Wolffian body. The peritoneum of the tubal ridge which covers the duct becomes thin like the adjacent peritoneum. As development continues the oviduct projects farther from the surface of the Wolffian body which soon degenerates. The oviduct is finally suspended by a ligament formed by a double sheet of peritoneum continuous at the dorsal margin of the oviduct with the peritoneum which surrounds the duct and reflected from the peritoneum covering the dorsal body wall and permanent kidney along the line of origin of the oviduct. At the end of incubation this sheet of peritoneum which suspends and surrounds the oviduct is continued a little below the ventral margin of the oviduct as a narrow fold. The part of this sheet of peritoneum dorsal to the duct may be designated as the *dorsal ligament of the oviduct* (Fig. 1) and the part ventral, as the *ventral ligament of the oviduct** (Fig. 1).

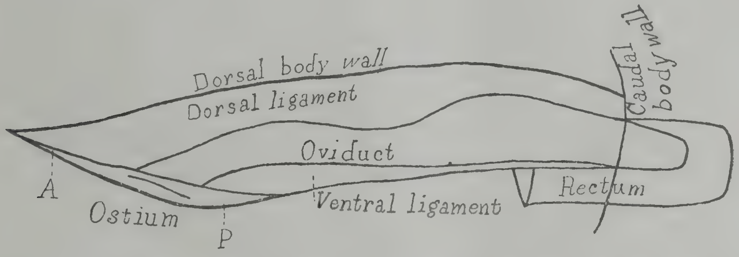

FIG. 1. Diagram showing relations of the oviduct and its ligaments at the time of hatching. *A*, anterior elongation of funnel; *P*, posterior elongation of funnel.

At the time of hatching the oviduct is still a straight thin walled tube somewhat differentiated into the parts clearly distinguishable in the functional duct. These are (a) the funnel

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* This fold of peritoneum which forms the ventral ligament occupies the position described for the tubal ridge and it seems possible that this ridge may contribute to its formation.

(*ostium tubae abdominale* or infundibulum), (b) the albumen secreting portion, (c) the isthmus, (d) the uterus (or shell gland) and (e) the vagina. The walls are thin and soft and the tube empty and collapsed. The duct usually appears flattened laterally so that the ligaments are attached at the ends of its greatest diameter. At its anterior end the tubular portion of the oviduct spreads out into the funnel. The mouth of the funnel lies in a diagonal position, relative to the longitudinal axis of the bird (cf. Fig. 1). This arises from the fact that the dorsal margin of the tubular portion of the duct extends farther forward than does the ventral.

Since the tube is collapsed laterally its mouth is a narrow slit-like opening. The angles of this opening lie at the mid-dorsal and mid-ventral margins of the duct, or at the attachments of the dorsal and ventral ligaments. The funnel is short except at the angles of the mouth of the tube where it is extended into narrow tongues of tissue. The short portions of the funnel are extensions of the medial and lateral halves of the duct and are sometimes called the lips of the funnel. The elongations of the funnel which arise at the angles of its mouth are continuous with the duct at its dorsal and ventral margins, and thus at the attachments of the ligaments. The peritoneum which covers the external surface of these elongations is continuous with the peritoneum forming the ligaments, in the same way as is the peritoneum covering the external surface of the tube. The anterior elongation of the funnel does not extend straight forward in the cranial direction, but instead turns laterad, forming an angle of about 30 degrees with the sagittal plane of the animal. It is suspended from the anterior lobe of the left kidney and the dorsal body wall by the cranial end of the dorsal ligament. The posterior elongation of the funnel runs caudad parallel to the oviduct and is suspended from the ventral margin of the duct by the cranial part of the ventral ligament. These attachments of the elongations of the funnel spread it out beneath the caudal and lateral angle of the ovary. The significance of this fact will be discussed in a later section of the paper (p. 12).

The line of reflection of the dorsal ligament from the body peritoneum runs in a cranial direction a little to the left of the median line of the body from the caudal end of the abdominal cavity, to the caudal end of the anterior lobe of the left kidney. At this point it turns slightly in a lateral direction, crossing diagonally the anterior lobe of the kidney. It continues in this direction to the fourth thoracic rib. This line of reflection is the dorsal margin of the ligament. The ligament begins to turn laterally at the level of the oviduct where the dorsal margin of the tubular portion of the duct passes into the anterior elongation of the funnel. Towards the cranial end of the dorsal ligament the distance between its attachment to the dorsal body wall, on the one hand, and to the funnel on the other hand, becomes gradually shorter. At the fourth thoracic rib the margin of the funnel itself is attached to the body wall. Thus the attachment of the funnel to the dorsal ligament forms the cranial margin of that ligament. Its ventral margin is its attachment to the tubular portion of the duct. Its caudal margin is its line of reflection from the peritoneum covering the caudal wall of the abdominal cavity.*

The relation of dorsal ligament and anterior elongation of the funnel of the oviduct to the abdominal air sac needs mention. At a point slightly mediad of the lateral margin of the kidney the line of reflection of the ligament reaches the part of the body wall to which the lateral margin of the abdominal sac is attached. From this point to the fourth thoracic rib the ligament and the anterior elongation of the funnel pass between the sac and the body wall. The elongation of the funnel projects into the sac and is surrounded by a fold of its wall. Usually even in young chicks this fold in the wall of the air sac is fused to the ligament. In some individuals the sac can be stripped off leaving the anterior elongation of the funnel suspended by the dorsal ligament.

In most cases these simple relations of the dorsal ligament exist essentially as described in just hatched or very young chicks. In some individuals at hatching, however, and in all cases examined at maturity, the peritoneum of the ligament is fused in certain places with the peritoneum of the air sac and mesentery. One such region of fusion has been described in the preceding paragraph. There is one other place where fusion takes place between the ligament and the dorsal wall of the air sac. This is a narrow strip along the dorsal margin of the ligament beginning where this structure passes between the sac and the body wall and extending caudad to the end of the sac. This fusion is often present in chicks just hatched and was found in all the specimens examined at sexual maturity. Fusion of the dorsal ligament and the mesentery is slight in extent and occurs only at the caudal end of the ligament between its medial surface and the lateral surface of the mesentery of the rectum.

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* In an adult hen the connective tissue core of the dorsal ligament extends through the layer of fat between the peritoneum and the caudal wall muscles. In this the ureter, blood vessels and nerves continue caudad.

The relations of the ventral ligament are always simple. Its dorsal margin is its line of attachment to the ventral margin of the oviduct. This margin extends as far craniad as does the tubular portion of the duct. Its cranial margin is its line of attachment to the posterior elongation of the funnel. At hatching the ligament is very narrow and nearly uniform in width throughout the greater portion of its course. It appears as a narrow band rounded slightly at the beginning of the funnel and limited ventrally at its cranial end by the posterior elongation of the funnel. Caudad to the end of the funnel the ventral margin of the ligament is free and slightly thickened. The two sheets of peritoneum forming the ligament are continuous at its free ventral margin. The ligament becomes narrower caudad and ends as a cord along the ventral margin of the uterus.

The Oviduct and its Ligaments in the Adult.

The ligaments of the oviduct always maintain the general relations described above. During the first four or five months after hatching the growth of the oviduct and its ligaments is about proportional to the growth of the rest of the body. With the approach of functional activity (egg laying) the isthmus, albumen secreting portion and funnel of the oviduct elongate considerably. This elongation includes the enclosing peritoneum. At their attachments to the duct the ligaments, of course, become elongated concurrently with the growth of the duct. At their opposite margins the ligaments do not elongate relatively but instead maintain the relations existing at the time of hatching. In other words, the dorsal ligament maintains a line of attachment to the body wall running from the caudal end of the body cavity to the fourth thoracic rib. The free ventral margin of the ventral ligament elongates very little during the growth period, but becomes thick and muscular. The distance between the attachment of the dorsal ligament to the body wall and to the duct increases, varying somewhat in different regions of the duct. The width of the ventral ligament from its attachment to the oviduct to its free ventral margin increases during growth except at its caudal end. Here the ligament becomes simply a heavy mass of muscle. Thus at sexual maturity the oviduct is suspended in a fold of peritoneum which remains short at its dorsal and ventral margins but which is elongated where it encloses the duct.

The relation of the oviduct to the sheet of peritoneum which forms the dorsal and ventral ligaments as well as the outer covering of the duct itself was described many years ago by Macartney in his article on "Birds" in Rees' Cyclopaedia, Vol. IV. His description is as follows: "The ovarian tube or oviduct during the season of laying, fills the greater part of the lower belly; it forms a number of curves or convolutions similar to the intestines, which, however, are not permitted the same latitude of motion amongst each other, because the prolongation of peritoneum which includes the oviduct is remarkably strong, and is not so long as the parts it contains and therefore the convolutions are coiled close together and even some of them are doubled up within the peritoneum. The disproportion between the oviduct and the peritoneum, which invests it, arises from the additional bulk the [oviduct] * acquires when its functions are exercised whilst the peritoneum must preserve at its back part its original extent, i. e., the length of the left kidney, from the middle of which it is reflected."

As a result of the enlargement incident to commencing functional activity the albumen secreting portion and the isthmus are thrown into convolutions. The anterior and posterior elongations of the funnel increase in length. The peritoneum covering the uterus elongates very little more than is necessitated

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* There is an obvious typographical error in the original text which here reads "ovary" instead of "oviduct."

by the growth of the body wall from which it is suspended.* In the region of the uterus the ventral margin of the dorsal ligament is only a little longer than its dorsal margin.

As a result of the growth changes which have been described in detail above both the dorsal and ventral ligaments of the oviduct come finally to have, in general, a fan shape. The truncated apices of the two "fans" are the dorsal and ventral margins of the dorsal and ventral ligaments respectively. The long, outspread borders of the "fans" are represented by the lines of attachment of the ligaments to the oviduct. The ventral ligament as a whole is strictly fan shaped. In the case of the dorsal ligament only the anterior portion is spread into a "fan." The fan shaped portion of the dorsal ligament is continuous caudad with the nearly straight portion which suspends the uterus.

The general relations of the ligaments which have been described are shown in Figures 6 and 7. Figure 6 shows the ventral ligament, and Figure 7 shows, besides a small portion of this, about three-fourths of the dorsal ligament (D). The method used in making the preparations from which these photographs were taken is described in a later section of the paper (p. 9).

At the functional period the ligaments are very vascular. In the region of the oviduct the large vessels break up into branches which pass forward and backward on the oviduct, often anastomosing with other branches either in the ligaments or on the walls of the oviduct.

THE MUSCULATURE OF THE LIGAMENTS OF THE OVIDUCT.

Early in the study of the ligaments of the oviduct it became clear that these structures contained a very considerable amount of smooth muscular tissue. Special attention was then devoted to a study of the character and distribution of this musculature.

At first histological sections were employed, but large surface mounts of the ligaments and adjacent oviduct walls also proved very valuable in determining the origin, direction and distribution of the muscle bundles. For such preparations oviducts were removed by cutting the peritoneum lining the dorsal body wall a little to either side of the line of reflection of the dorsal ligament. This peritoneum was then stripped off the body wall and kidney. One-half of the oviduct was then cut away at its dorsal and ventral margins leaving the other half attached to the ligaments. The portions of the duct and ligaments desired for study were selected. From these the glandular part of the wall of the oviduct was removed by careful scraping. By exercising sufficient care in this operation it is possible to remove practically all of the glandular part of the wall, and leave the underlying muscular and peritoneal layers intact.

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* The glandular surface of the uterus is increased by the elongation of the inner layers of the oviduct which are thrown into folds within the peritoneum.

Such preparations were fixed in two different ways. When the specimen was intended for microscopic study it was carefully spread out on a wax bottomed dissecting pan and exposed to the action of osmic acid vapor for from 15 to 20 minutes. The hardened sheet of tissue was then washed for 3 or 4 hours in running water, then stained in picro-haematoxylin (Conklin), dehydrated, cleared in cedar oil and mounted in balsam between ordinary "3¼x4" lantern slide covers. Specimens to be used for macroscopic examination, and to be photographed (cf. figures 6-9), were fixed in Gilson's mercuro-nitric fluid after first being carefully stretched in a wax bottomed dish. The time of fixation was from 18 to 24 hours. This method of fixation renders the muscle fibers white and when treated with alcohol the other parts of the ligament become nearly transparent. When these preparations are placed against a black background the muscle bundles and blood vessels stand out very sharply. Such Gilson specimens were usually not permanently mounted but simply spread out on a black background for study or to be photographed.

By means of these various preparations it was possible to determine the extent of the musculature of the ligaments and the relation of this to the intrinsic musculature of the oviduct. This musculature is best developed and hence easiest studied when the hen is in laying condition.

The muscle fibers of the dorsal ligament have their origins in a line near the medial side of its dorsal margin. Here the bundles of muscle fibers are quite large but as they pass ventrad toward the duct they spread out in the ligament, breaking up into smaller bundles. These smaller bundles anastomose frequently as they approach the oviduct (figures 7, 8 and 9). At the attachment of this ligament to the oviduct these bands of fibers continue around the duct. Most of them pass to the medial side (figures 8, 9.).

The free ventral margin of the ventral ligament in the laying hen is a solid muscular cord 3 to 6 mm. in diameter. This cord becomes heavier toward the caudal end of the ligament. From this cord bundles of fibers extend on either side toward the oviduct in much the same way as has already been described for the muscle bundles on the medial side of the dorsal ligament. These fibers continue around the oviduct. Some of the fibers pass to the medial and some to the lateral side of the duct.

Most of the above points are shown in the preparations of which figures 6-9 are photographs. Figures 6 and 7, which have been used to show the shape of the ligaments at sexual maturity also show the musculature of the ligaments. Figure 6 is a photograph of the ventral ligament. It shows the heavy muscular cord at the free ventral margin. This cord is much heavier at the caudal than at the cranial end. From this cord the interwoven bundles are seen separating, breaking up into smaller bundles and spreading out in the ligament as they pass toward the oviduct. Near the margin from which the duct has been cut many of the fibers are seen anastomosing.

Figure 7 shows the origin of the separate muscle bundles near the dorsal margin of the dorsal ligament. This photograph is taken from the lateral side of the duct so that the muscle origins here show through the air sac wall and the peritoneum of the lateral side of the ligament. These bundles are seen breaking up into smaller bundles and the small bundles are seen anastomosing as they pass to the duct. In the anterior portion where the funnel and anterior end of the duct are attached some of the muscle bundles can be followed as they pass onto the wall of the duct.

Figures 8 and 9 are photographs of opposite sides of the same preparation. This preparation is a piece of the medial half of the caudal end of the isthmus and the attached ligaments of the oviduct of a laying hen. The lateral half of the oviduct has been removed and the glandular layer scraped from the medial half. Figure 8 is a photograph of the lateral aspect of this preparation. The dorsal ligament lies toward the top and the ventral ligament toward the bottom of the photograph. The left margin is the anterior end of this piece of the oviduct and ligaments. The heavy muscular mass which shows at the bottom of the photograph is the caudal end of the free margin of the ventral ligament. From this the fiber bundles pass out into the ligament and separate into smaller bundles as the oviduct is approached. The cut ends of some of the fiber bundles appear, rather indistinctly, where the lateral wall of the duct was cut away. Some of the bundles can be traced onto the medial wall of the oviduct where they lie below the circular fibers which also appear in the photograph. In the dorsal ligament most of the muscle fibers lie below the blood vessels but some of them accompany these vessels. At the margin of the oviduct many of these fibers can be seen passing beneath the layer of circular fibers.

Figure 9 shows the medial aspect of the same preparation figured in Figure 8. The dorsal ligament lies toward the top and the ventral toward the bottom as before. In Figure 9, however, the anterior end of the preparation lies to the right. The continuation of the muscle bundles from the ligaments to the duct show more clearly than in Figure 8 since they here lie above the intrinsic circular fibers of the duct. The fiber bundles in the dorsal ligament show above the blood vessels. The origins of these bundles are seen near the dorsal margin of the ligament. The origin of a number of the bundles shown in this preparation are crowded together near the center of the part of the dorsal margin which is shown here.

Sections of a young oviduct with the ligaments attached show these bundles of muscle fibers arranged in layers near the peritoneal surfaces of the ligaments. These layers of muscle bundles are continuous with the outer muscular layer of the wall of the oviduct. The ventral ligament, as has been noted, has a heavy mass of muscle bundles near its free margin. This mass of muscle separates into two distinct layers, one near the peritoneum of each side of the ligament. At the ventral margin of the duct these muscle layers continue around it, each preserving the same relation to the peritoneum which it has in the ligament In chicks up to 4 months old, at least, the two layers of muscles which pass to either side of the duct are nearly equal in thickness. In the dorsal ligament, however, the majority of the muscle bundles are in relation to the peritoneum on the medial side of the ligament and are continuous with the muscle layer on that side of the oviduct.

From the facts which have been brought out in this section it appears that in the domestic fowl the outer muscle layer of the oviduct is continuous with the muscle fibers from the ligaments. This is similar to the condition in mammals where the outer longitudinal layer of muscle of the uterus develops from the muscle fibers in the broad ligament.*

The Normal Relations of the Cranial End of the Oviduct and its Ligaments to the Ovary, and the Significance of These Relations.

In all vertebrate animals the ovum at the time of ovulation is, theoretically, cast off from the ovary into the abdominal cavity. From the abdominal cavity it must get to the outside through the oviduct. It is obviously of the highest importance that the ovum should practically never fail to get into the oviduct. There exist among the different vertebrate classes a whole series of different structures and modes of physiological behavior, if this term may be used, apparently adapted to ensure this result. Thus in mammals the fimbriated funnel of the Fallopian tube wraps itself around the ovary at ovulation in such a way that while theoretically the egg drops from the ovary into the abdominal cavity, practically it drops into the oviduct.

In the course of the present anatomical study it has been found that the normal visceral relations in a laying hen are such that the ovary is practically walled off by peritoneal surfaces from the rest of the abdominal cavity. Practically the only line of egress from the "ovarian pocket" presently to be described, is through the *ostium tubae abdominale* of the oviduct. In other words it is easy of demonstration that so far as the *anatomical* relations are concerned, an egg discharged from the ovary cannot get far away from the funnel of the oviduct. Without any reference to the *activity* of the funnel itself the eggs separated from the ovary would as a mechanical necessity from the normal anatomical relations be brought close to its mouth. It is the purpose of this section to describe these relations and to show how this "ovarian pocket" is formed.

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* Cf. Kreitzer. Anatomische Untersuchungen über die Muskulatur der nicht schwangeren Gebärmutter. Land. Beitr. zur Anat. und Histol. St. Petersburg, 1872.

Heyken, G. Anatomische Untersuchungen über die Muskulatur der breiten Mutterbänder. Gekr. Preisschr., Inaug.—Dissert. Kiel, 1890.

An excellent general account of this mammalian musculature is given in Nagel, W., Die weiblichen Geschlechtsorgane, in Bardeleben's Handbuchs der. Anatomie des Menschen, 7 Bd, II Teil, 1 Abteilung. Jena (Fischer) 1896.

The walling off of the ovary in the hen is effected by the left abdominal air sac and a part of the intestine and mesentery. These structures in their mutual relations form what may be called a "pocket" in which the ovary lies. The dorsal wall of this "pocket" is formed by the body wall to which the ovary is attached. The ventral wall of the "pocket" is formed by the dorsal wall of the air sac. The medial, cranial and lateral limits of the pocket are formed by a fusion of the wall of the air sac to the mesentery and body wall. Caudad the boundary is composed of the transverse part of the small intestine and the caudal portion of the left coecum with their attached mesentery and peritoneum. There is a small open space dorsal to the junction of the left coecum and rectum and lateral to the rectum. In this space lies the mouth of the funnel. The oviduct which lies to the left of the rectum and its mesentery here passes into the funnel.

The detailed description of these relations follows. The left abdominal air sac extends from the anterior end of the abdominal cavity as far caudad as a line connecting the caudal end of the gizzard with the caudal end of the pubis. It is as wide as the left half of the cavity extending from the mesentery to the lateral body wall. This sac is attached in a band around its medial, cranial and lateral margins. Its caudal margin and dorsal and ventral surfaces are free. Mesially this attachment is to the mesentery connecting the left coecum to the dorsal margin of the gizzard and also to the mesentery of the proventriculus, or glandular portion of the stomach. At the anterior end of the body cavity the attachment of the air sac passes to the body wall and runs in front of the anterior end of the ovary and suprarenal body. At the craniolateral angle of the body cavity the band of attachment passes in a widening belt along the lateral side of the ovary and oviduct as far backward as the caudal margin of the sac. This lateral attachment of the sac is to the kidney, dorsal oviduct ligament, and body wall.

The air sac thus forms a partition to the body cavity complete as far caudad as it extends.* Ventral to the sac lie the left lobe of the liver, the proventriculus, the spleen and the gizzard, while the cavity dorsal to the sac contains the ovary and parts of the intestine and oviduct. In the normal condition the sac contains little air and clings to the organs which lie dorsal to it. The ovary occupies the anterior end of the cavity dorsal to the sac. Since the attachment of the air sac passes along the medial, cranial and lateral margins of the ovary, this organ is walled off from the other viscera in all directions except caudally by the anterior portion of this sac.

The caudal relation of the ovary to the rest of the viscera depends on its size. It changes as the ovary enlarges with the approach of a laying period or egg cycle. In pullets and hens not in laying condition the reproductive organs are small and the other viscera occupy most of the abdominal cavity. A part of the intestines crowd forward between the ovary and the air sac. The viscera normally found in this position are the transverse part of the small intestine and that portion of the left coecum which lies parallel to it.† The mesentery of this part of the intestine is reflected from the body wall just caudal to the attachment of the ovary. Mesially it is fused with the mesentery of the proventriculus and laterally it is continuous with the mesentery of the rectum at the junction of the small intestine and rectum. The coeca lie parallel to the most caudal portion of the small intestine, to which they are attached by peritoneum. They enter opposite sides of the rectum just behind the ileocolic valve. Where the coeca parallel the transverse part of the small intestine the left one lies craniad and ventrad to the intestine. The right coecum lies caudal and dorsal to it. The left coecum thus lies farther forward on the ovary than does the intestine.

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* Butler (Proc. Zool. Soc. London, 1889, pp. 452-474, Plates XLVI-XLIX) describes and figures on both sides in both sexes of the chick a partition which he calls the *oblique abdominal septum* or the *anterior part of the post hepatic septum.* He shows by a study of the embryology that this septum develops in connection with the abdominal air sacs which grow between and separate its two layers of peritoneum. In the adult this septum is apparently represented by the peritoneum covering the sacs. He does not discuss the relation of this partition to the viscera but his figures show the gonads lying dorsal to it. On the left side of the female they show the ovary shut off from the viscera by the sac. In the present paper this partition of the left side of the female is described as it appears in the adult, i. e., as the left abdominal air sac.

†In two individuals this part of the intestine and coecum was found to lie caudal to the ovary and dorsal to a loop of the small intestine which projected forward ventral to the ovary. In neither of these cases were there large yolks on the ovary.

When a laying period is approached the growing yolks on the ovary crowd the viscera caudad. The intestine and coecum are forced backward and downward from the ovary. The mesentery of the intestine, the intestine itself, the peritoneum joining the left coecum of the intestine, and the left coecum itself, form a partition between the ovary and the other viscera. This partition is incomplete dorsal to the end of the left coecum and lateral to the anterior end of the rectum. This space is at the caudolateral angle of the ovary and here the mouth of the funnel is spread out facing that organ. It is thus in the position most advantageous to receive the mature yolks.

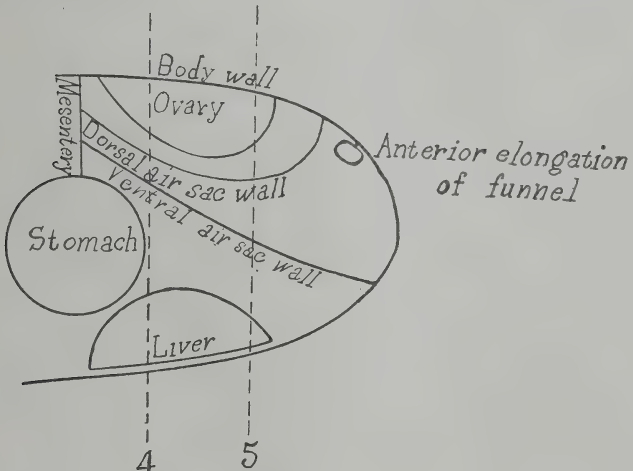

FIG. 2. Diagram of a cross-section of the left half of the body of a hen in a plane cranial to the mouth of the funnel of the oviduct.

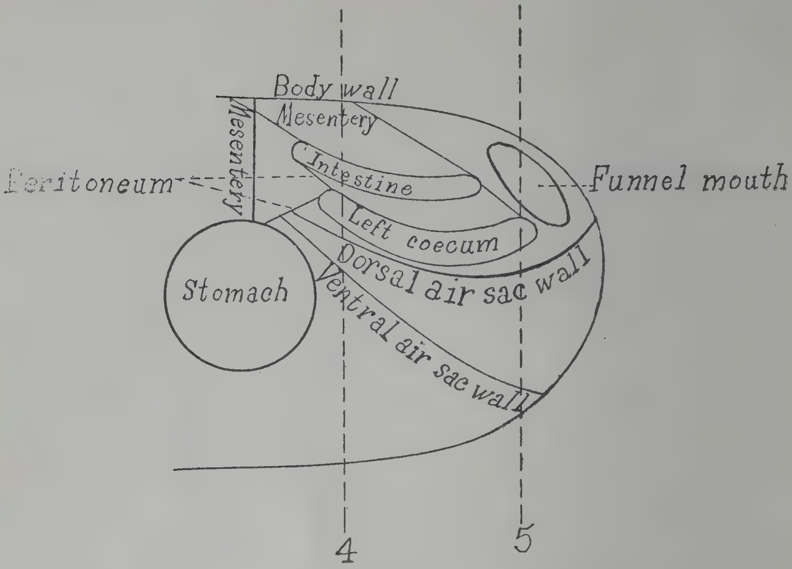

FIG. 3. Like Fig. 2, but showing the relations of the viscera in a plane just caudal to the ovary and through the mouth of the funnel of the oviduct.

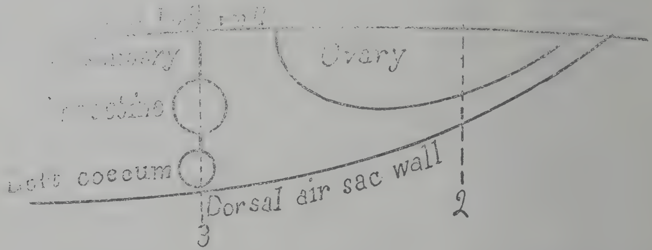

FIG. 4. Diagram of a portion of a longitudinal section through the left side of the body of a hen. The plane of section is slightly mediad of the funnel mouth.

Figures 2, 3, 4, and 5 are diagrams representing the relation of the ovary to the air sac, the intestine, the left coecum and the mesentery, and to the mouth of the funnel. Figure 2 represents a cross section near the anterior end of the sac. It shows the ovary lying dorsal to the sac which is attached to

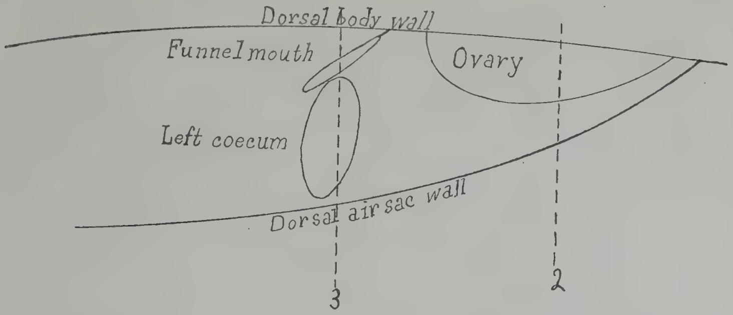

FIG. 5. Like Fig. 4 except that the plane of section is here farther laterad and goes through the funnel mouth.

the mesentery and lateral body wall. The anterior prolongation of the funnel lies between the air sac and the body wall lateral to the dorsal line of the band of attachment of the sac. Figure 3 is a diagram of a cross-section caudal to the ovary through the coecum, intestine and mesentery, which wall off the ovary caudad. It shows the coecum lying against the dorsal wall of the sac and connected to the transverse part of the small intestine; the transverse part of the intestine with its mesentery; the fusion of this mesentery with the mesentery of the stomach; and the peritoneal connection of the coecum to the dorsal wall of the gizzard, to which the medial margin of the air sac is here attached. The mouth of the funnel is shown dorsal to the end of the coecum and lateral to the intestine and its mesentery.

Figure 4 represents a longitudinal section through the "ovarian pocket" mediad of the mouth of the funnel. It shows the ovary lying dorsal to the air sac and walled off behind by the coecum and intestine with their attached peritoneum and mesentery. Figure 5 represents a similar longitudinal section through the mouth of the funnel. It shows the ovary dorsal to the wall of the sac and the funnel caudal to the ovary and dorsal to the end of the coecum.

The dotted lines numbered 4 and 5 in figures 2 and 3 represent the planes of the sections shown in figures 4 and 5 respectively. The dotted lines numbered 2 and 3 in figures 4 and 5 represent the planes of the section shown in figures 2 and 3 respectively.

The walling in of the ovary in all directions except the one occupied by the mouth of the oviduct in the manner described must tend to decrease the chance of yolks getting free in the body cavity. Even with this arrangement such an accident sometimes happens. In autopsies of a large number of laying hens in a few cases yolks have been found among the viscera. Tumors which appeared to be formed around such yolks have also occasionally been found. It is not possible with our present knowledge to draw conclusions as to the extent of this apparent structural adaptation among birds. Even in the species where the air sacs have been carefully studied, the description of their attachments and position in relation to the viscera have not been given in detail. From such descriptions as exist it appears that the left abdominal air sac does not uniformly isolate the genital organs so completely as is here described for the domestic fowl.

Owen* states that "the air receptacles of the thoracic-abdominal cavity present varieties in their relative sizes and modes of attachment in different birds" (meaning different species). Muller ** states that in the pigeon the walls of the abdominal air sacs are almost entirely free. Baer† has demonstrated that the abdominal air sacs are absent in the cassowary. Data are wanting as to whether the oblique abdominal septum of Butler occurs in these cases. It is possible that this septum occurs throughout the class *Aves* even when the abdominal air sacs bear other relations than those described in the domestic fowl, or even when they are absent.

The general result of this section of the paper is to show, with detailed anatomical description of the relations involved, that there is formed in the hen a sort of "pocket" in which the ovary lies. This "pocket" is of such a nature that, quite apart from any physiological activity on the part of the funnel of the oviduct, the ova separated from the ovary at ovulation are mechanically directed towards the funnel mouth.

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* Owen, R. On the Anatomy of Vertebrates. Vol. II. Birds and Mammals. London (Longmans) 1866.

** Müller, B. The Air Sacs of the Pigeon. Smithsonian Misc. Col. Quarterly Issue, Vol. 50, Part 3, No. 1724, pp. 365-414.

† Baer, M. Beiträge zur Kenntnis der Anatomie und Physiologie der Atemwerkzeuge bei den Vögeln. Ztschr. wiss. Zool. Bd. 61.

SUMMARY.

This paper presents the results of a detailed anatomical study of the ligaments of the oviduct of the domestic fowl.

It is shown that the dorsal and ventral ligaments undergo a progressive change in shape and size relations as the oviduct enlarges in preparation for functional activity. The character of these changes is described.

It is further shown that the ligaments of the oviduct possess a definite and well developed musculature which is continuous with the outer muscular layer of the oviduct. The physiology of this musculature of the ligaments is now under investigation in this laboratory.

Finally it is shown that the mutual relations of the abdominal viscera are such as virtually to form a "pocket" in which the ovary lies. This walling off of the ovary is of such character as to tend mechanically to direct detached ova to the mouth of the oviduct.

DESCRIPTION OF PLATES.

Figure 6. A photograph of the ventral ligament of the oviduct of a laying hen showing its form and musculature. The ragged outer border is the cut dorsal margin, i. e., the margin along the oviduct. The short smooth border in the center of the photograph is the free ventral margin. The thin cut surface extending from the ventral to the dorsal margin of the ligament is the anterior margin cut along its attachment to the posterior elongation of the funnel. The thick wedge-shaped portion which shows at the opposite end of the ventral margin is the caudal end of the ligament cut from the anterior end of the uterus. This photograph is natural size.

Figure 7. A photograph showing the form and musculature of the funnel, a short portion of the tubular part of the oviduct, and the anterior portion of both ligaments removed from a laying hen. The dorsal ligament is shown for about three-fourths of its length. The lateral half of the oviduct is cut away along the attachment of the ligaments. The glandular layer of the duct was scraped away (cf. p. 9) in the tubular portion of the duct leaving only the muscular and peritoneal layers.

The significance of the letters in this figure is as follows: A, anterior elongation of funnel; P, posterior elongation of funnel; F, funnel (*ostium tubae abdominale*); D, dorsal ligament; O, one half (left) of wall of anterior tubular portion of the oviduct, from which the glandular part of the wall has been removed by scraping; S, portion of the air sac wall.

The anterior margin of the dorsal ligament shows along the attachment to the anterior prolongation of the funnel. The ventral margin shows along the attachment to the tubular portion of the duct as far as this goes, and then as a cut edge from which the duct has been removed. In order to spread the dorsal ligament out flat in this preparation a cut was made near the posterior end of the dorsal margin extending about half way to the ventral margin. This cut shows just to the right of the end of the anterior elongation of the funnel.

A portion of the wall of the air sac (S) which is fused to the dorsal part of the ligament is left attached. It is spread back toward the dorsal margin of the ligament and is so transparent that it shows only beyond the margin of the ligament and between the edges of the cut made to flatten the latter. The ventral margin of the band of fusion can be distinctly seen. This photograph is about four-fifths natural size.

Figure 8. A photograph showing the musculature of the medial half of the caudal end of the isthmus and the portions of the dorsal and ventral ligaments which attach to it. The lateral half of this portion of the duct was removed by cutting it along the attachment of the dorsal and ventral ligaments. The glandular layer of the oviduct was scraped away leaving only the muscular and peritoneal layers. In the photograph the dorsal ligament lies above and the ventral ligament below the oviduct. The anterior end of the preparation lies to the left. This photograph shows the lateral aspect of the preparation. Natural size.

Figure 9. A photograph of the medial aspect of the same preparation shown in lateral view in Figure 9. The dorsal ligament lies above and the ventral ligament below the oviduct as in figure 8. The anterior end of the preparation lies to the right. Natural size.

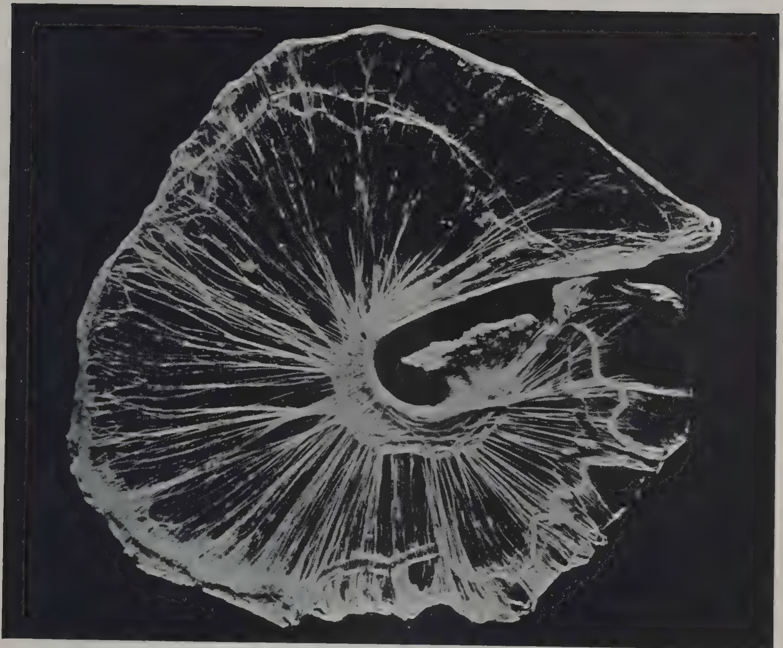

Figure 6

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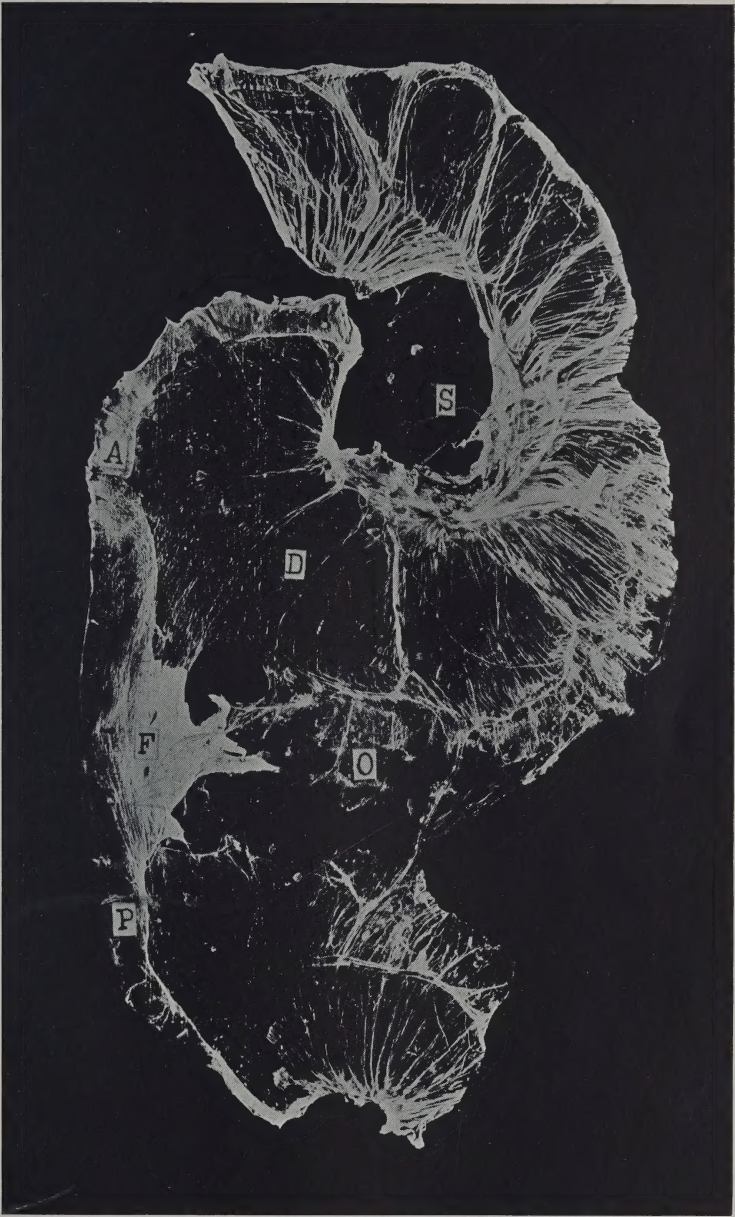

FIGURE 7

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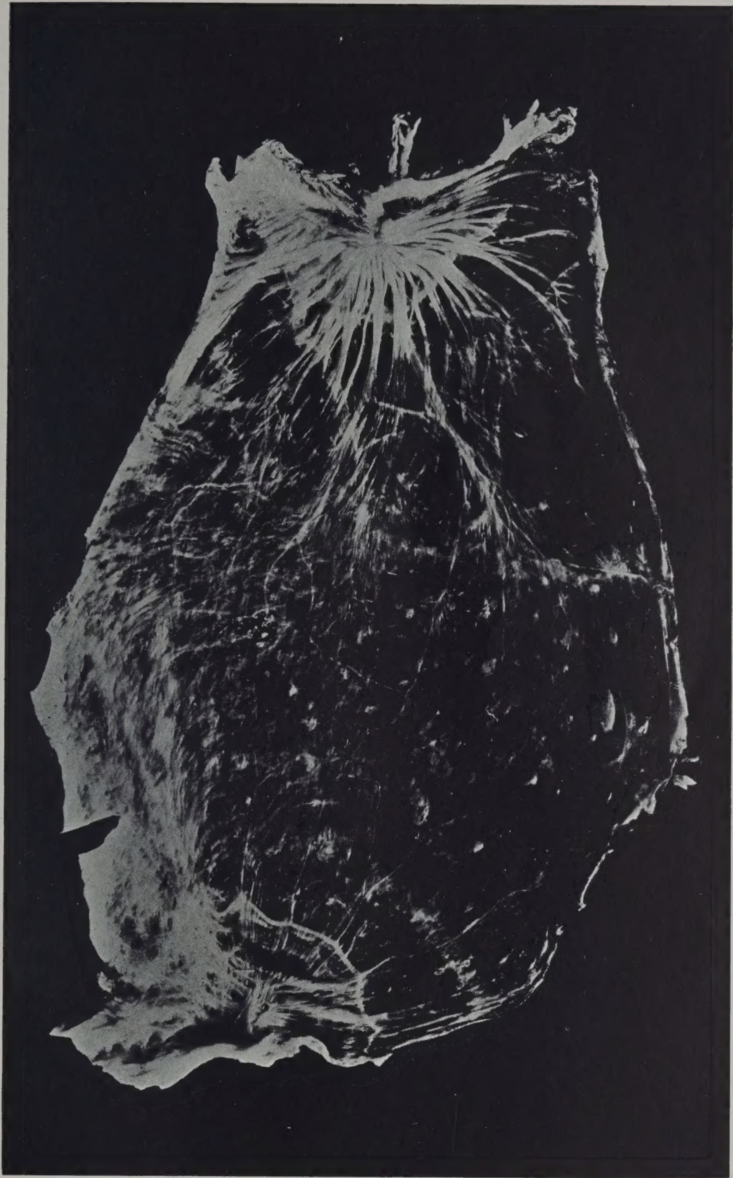

FIGURE 9

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